

## SYSTEM AND METHOD FOR RADIO RESOURCE MANAGEMENT IN A COMMUNICATION SYSTEM

### FIELD OF THE INVENTION

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The present invention relates to communication systems and methods, and more particularly it relates to systems and methods for managing radio resources in a multi-access communication system.

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### BACKGROUND OF THE INVENTION

In a communication system, a radio access network comprises multiple entities or nodes that co-operate in order to use the available radio resources in an efficient way. A co-operation is necessary for being able to take care of communication from and to terminals over the radio access network. The degree of cooperation is dependent on the design goal for the radio access network, such as simplicity, optimal use of available radio resources etc. This cooperation is taken care of by radio resource management functions at different levels of the system.

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The radio resource management decisions are often based on input from multiple nodes in the network. For example, a radio network controller (RNC) in a WCDMA network makes radio resource management decisions based on inputs both from terminals, Node B's and other RNC's. For example, if a terminal is a candidate for doing a handover from one cell to another, the RNC needs to know the received signal quality at the terminal for signals from the two Node B's covering the two cells. The signal quality is measured at the terminals and the measurements are sent as input for the radio resource management to the RNC. The RNC also needs to know the load of the different Node B's, i.e. if any of the Node B's is close to using all its resources for other communications.

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Future communication systems will be multi-access systems, i.e. the communication systems will include overlapping radio access networks using different access technologies, for example a communication system may comprise a WCDMA network, a GSM network and a Wireless Local Area Network (WLAN) covering the same area.

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Multi-access systems have emerged because it is hard to design one single access technology suitable for all kinds of services and all deployment scenarios in a

communication system (e.g. personal area networks, indoor areas, hotspots, wide area networks etc.). It is also costly to replace previous generations of systems because the operator may lose existing customer base and because the systems are widely deployed. Furthermore, spectrum is in some cases allocated to a specific access technology.

In order to be able to connect a terminal in a multi-access communication system to the access network that has the best connection for the user's current communication purpose, there is a need to coordinate radio resource management for the different access networks in the multi-access communication system.

In the 3GPP standardisation prior art document 3GPP TS 25.413 v5.6.0 there is discussed a network based radio resource management system for the support of handover between WCDMA and GSM networks. When a radio network controller (RNC) in the WCDMA network detects that a handover is imminent from a WCDMA cell to a target GSM cell, the measured load of the current WCDMA cell is sent to the GSM network base station controller (BSC) controlling the area where the target GSM cell is situated. The measured load is sent via the core network over an existing interface called Iu. The load of the current WCDMA cell is normalised towards a linear scale (0-100) where 100 represents the maximum planned load. The GSM network then uses the load of the WCDMA cell to compare to its own cell load to judge whether it would be worth to handover the terminal to the GSM cell or not. In case the BSC decides not to go forward with the handover it may send the load of the GSM cell to the WCDMA network. This prior art document does not describe any coordinated radio resource management for the two networks more than coordination between cells involved in a handover. I.e. there is no common radio resource management function for the two networks.

In a second prior art document from the 3GPP standardisation body, called 3GPP TR 25.891 V0.3.0, enhancements to the system described in the above mentioned document is shown. In this second prior art document, a common radio resource management server (CRRM server) is described that may collect cell load measurement information from the RNCs in the WCDMA network and from the BSCs in the GSM network. These measurements may then be used to either take centralised handover decisions in the CRRM server or provide handover policy information from the CRRM server to the radio resource management functions in the

RNCs that manage radio resources within the WCDMA network, and to the radio resource management functions in the BSCs that manage radio resources within the GSM network. The CRRM server may be either centralised as a stand-alone server or it may be distributed and integrated with every RNC/BSC or integrated only in some RNCs and/or BSCs. Therefore, this document has described a protocol for distributing cell load measurements to both a centralised CRRM server as well as between CRRM entities. Although, no measurements from the terminals are distributed to the CRRM server.

The enhanced system for managing radio resources described in this second prior art document uses a standardised protocol defining which information that should be sent in messages between the CRRM server and the different nodes in the GSM and the WCDMA network. With the CRRM server a management node is achieved that manage radio resources between a GSM and a WCDMA network. Although, if another network is to be attached to this communication system, for example a WLAN network, it would be necessary to standardise all interfaces between the new network and the CRRM server. Consequently, this system for managing radio resources is not easily expandable to manage radio resources in a communication system consisting of access networks using other access technologies than GSM or WCDMA. In addition, since no terminal measurements are distributed to the CRRM server, consequently the CRRM server does not take such measurements into consideration when managing radio resources.

In the future, new access technologies will emerge that need to be merged into a multi-access communication system. One example of such an access technology that has recently emerged is wireless LAN. Therefore, and since there is an interest for both network operators and users to achieve a system where a user's terminal could access the communication system via all available access technologies, there is a need for a method and a system for managing radio resources in a multi-access communication system that easily could be expanded with new access technologies.

## SUMMARY OF THE INVENTION

As mentioned above, a modern communication system consists of access networks  
5 using different access technologies. The radio resources in the communication system  
need to be managed in order to connect a terminal in the system to the access  
network that has the best connection for the user's current communication purpose,  
and in order to achieve efficient use of the radio resources in the communication  
10 system. The solutions of today are especially configured to each access technology in  
the system such that each interface to a common radio resource handler is  
standardised. Therefore, if a new access network using a new access technology is to  
be merged into the system, with today's solution all new interfaces to the common  
radio resource handler needs to be standardised for the radio resource handler to be  
15 able to talk to the different nodes in the new access network. Consequently, great  
effort is needed and a long time will elapse before it is possible to merge a new access  
technology into such a solution.

An object of the invention is to achieve a solution for managing radio resources for  
providing wireless access to a communication system consisting of access networks  
20 using different access technologies, and wherein the solution can easily be adapted to  
manage radio resources for providing wireless access to a system that is expanded  
with new access networks using new access technologies.

The above stated object is achieved by means of a method according to claim 1, a  
25 system according to claim 13 and a listening agent according to claim 25.

The solution according to the present invention makes it possible to manage radio  
resources in a communication system consisting of access networks using different  
access technologies. By extracting access relevant information from existing messages  
30 within an access network, a new access network using a new technology can easily be  
added to the communication system and managed by a solution for managing radio  
resources according to the invention.

According to a first aspect of the present invention, a method is provided for managing  
35 radio resources for providing wireless access to a communication system to a number  
of terminals. The communication system comprises a first access network using a first

access technology and at least one second access network using at least one second access technology different from the first access technology. The method comprises the step of receiving access relevant information from the first access network and the at least one second access network, wherein the received access relevant information  
5 comprises information extracted from messages sent within the first access network. The method further comprises the step of comparing the received access relevant information extracted from messages sent within the first access network to access relevant information received from the at least one second access network. The method also comprises the step of determining which access network a terminal  
10 should access, based at least on the comparison of the received access relevant information extracted from messages sent within the first access network to the access relevant information received from the at least one second access network.

According to a second aspect of the invention, a system is provided for managing radio  
15 resources for providing wireless access to a communication system to a number of terminals. The communication system comprises a first access network using a first access technology and at least one second access network using at least one second access technology different to the first access technology. The system for managing radio resources comprises at least one listening agent arranged for extracting access  
20 relevant information for at least the first access network from messages sent within at least the first access network and sending the access relevant information to an access selection manager. The system for managing radio resources also comprises an access selection manager arranged for comparing the received access relevant information extracted from the first access network to access relevant information  
25 received from the at least one second access network. The access selection manager is also arranged for determining which of the first access network and the at least one second access network a terminal should access based at least on the comparison of the access relevant information extracted from the first access network to the access relevant information received from the at least one second access network.

30 According to a third aspect of the invention, a listening agent is provided for that is used in a system for managing radio resources for providing wireless access to a communication system to a number of terminals, wherein the communication system comprises a first access network using a first access technology and at least one  
35 second access network using at least one second access technology different to the first access technology. The listening agent is arranged for extracting access relevant

information for at least the first access network from messages sent within at least the first access network. The listening agent is also arranged for sending the access relevant information to an access selection manager.

- 5 According to a preferred embodiment of the invention, the access relevant information is found by sniffing the messages sent within the first access network.

10 An advantage of the invention is that it achieves efficient radio resource management in a multi-access communication system that is expanded with a new access network using a different access technology than used before in the system. Especially the invention achieves efficient radio resource management in a multi-access communication system comprising Wireless LANs and GSM and/or WCDMA networks.

- 15 A further advantage of the invention is that it makes it possible to use equipment in the new access network developed by different vendors without demanding standardisation of any new interfaces.

20 Further advantages of embodiments of the present invention will become apparent when reading the following detailed description in conjunction with the drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

- 25 Figure 1 shows a schematic block diagram of a communication system wherein the present invention may be used.

Figure 2 is a schematic block diagram illustrating an embodiment of the present invention for managing radio resources in a multi-access communication system.

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Figure 3 shows a schematic block diagram of a listening agent and an access selection manager for managing radio resources according to an embodiment of the invention.

- 35 Figure 4 shows a schematic block diagram of a GSM/WCDMA network with existing internal interfaces wherein the present invention may be used.

Figure 5 is a schematic block diagram illustrating a preferred embodiment of the invention where a listening agent is placed in a Layer 2 Switch in a WLAN network.

Figure 6 shows a diagram of the content of an IAPP ADD-notify message sent within  
5 WLAN networks.

Figure 7 shows a diagram of the content of an IAPP MOVE-notify message sent within WLAN networks.

Figure 8 shows a diagram of the content of a Layer 2 update frame message sent  
10 within WLAN networks.

Figure 9 shows a flowchart describing a method according to an embodiment of the  
15 present invention.

#### DETAILED DESCRIPTION

The present invention will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown.

20 This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention as defined in the appended claims to those skilled in the art. In the drawings, like numbers refer to like elements.

25 Figure 1 shows a typical multi access communication system where the present invention may be used, comprising a WCDMA/GSM network 110 and a WLAN network 120. The figure also shows a terminal 130 capable of communicating with both the WCDMA/GSM network 110 and the WLAN network 120. The terminal 130  
30 comprises a terminal equipment 131, which is for example a general purpose computer such as a Personal Digital Assistant (PDA) or a laptop, and a mobile terminal 132, 133 containing access specific functions for accessing each different access technology network. In the figure, the access specific functions comprises a WLAN transceiver (WLAN-MT) 133 for communicating with the WLAN network 120  
35 and a combined WCDMA/GSM transceiver (WCDMA/GSM-MT) 132 for communicating with the WCDMA/GSM network.

On the network side, the WCDMA/GSM network 110 comprises among other things, an access router 111, which is responsible for routing IP packets between an IP backbone network 140 and the WCDMA/GSM network 110. The WCDMA/GSM network 110 also comprises a core network 112 handling for example the communication between the GSM domain of the network 110 and the WCDMA domain of the network 110. The GSM domain of the network comprises among other things at least one base station controller (BSC) 116 and base transceiver stations (BTS) 117, 118 connected to the at least one BSC 116. The WCDMA domain of the network comprises among other things at least one radio network controller (RNC) 113 and Node B's 114, 115 connected to the at least one RNC 113. The Node B's 114, 115 cover certain WCDMA cells and the BTS's 117, 118 cover certain GSM cells. The WCDMA/GSM-MT 132 communicates with a respective Node B and/or BTS depending on the geographical position of the terminal 130.

The WLAN network 120 comprises an access router 121, which is responsible for routing IP packets between the IP backbone network and the WCDMA/GSM network. The WLAN network also comprises at least one Layer 2 switch 122, 123 and access points 124, 125, 126, 127. The access points handles the physical transmission and reception to/from the WLAN-MT 133 as well as the medium access control (MAC) functions such as retransmission of radio frames. The WLAN-MT 133 communicates with a respective access point 124, 125, 126, 127 depending on the geographical position of the terminal 130 and the current communication purpose of the user of the terminal.

In order to e.g. be able to connect a terminal in a multi-access communication system to the access network that has the best connection for the user's current communication purpose, there is a need to coordinate radio resource management for the different access networks in the multi-access communication system. In addition to consider the best possible connection for the user, there is also a need to coordinate radio resource management with the purpose of maximizing system performance. Also, there may be other reasons to coordinate the radio resources in a communication system, for example the radio resources may be coordinated with the purpose of prioritizing certain operator services etc.



For these purposes, there is a need to collect and evaluate access relevant information describing the state of the different networks. This access relevant information could be e.g. radio signal measurements, such as signal strength, regarding the radio connection between a terminal and an access point, base station or equivalent node.

5 The access relevant information could also be e.g. any type of system load measurements, such as the load of an access point, base station or equivalent node. The access relevant information for the different networks needs to be collected and compared to be able to provide the best connection to the terminal of a user.

10 According to the invention, the access relevant information from at least a first access network is extracted from messages sent within at least the first access network. Thereafter, the access relevant information from at least the first access network is compared to the access relevant information received from the at least one second access network, and further it is determined which access network a terminal should  
15 access based on the comparison of the access relevant information extracted from messages sent within the first access network to the access relevant information received from the at least one second access network.

Figure 2 shows a schematic block diagram of a system according to an exemplary  
20 embodiment of the invention for managing radio resources for providing wireless access to a multi-access communication system to a number of terminals. In figure 2, the WLAN-MT 133 of a terminal 130 measures a WLAN radio signal quantity, e.g. WLAN signal strength (SS) and sends the WLAN SS measurement value to the WLAN network 120. The WCDMA-MT 132 of the terminal 130 measures a WCDMA radio  
25 signal quantity, e.g. WCDMA signal strength (SS), and sends the WCDMA SS measurement value to the WCDMA network 110.

According to this exemplary embodiment of the invention, a number of first listening agents 203 placed in the WLAN network 120 sniffs existing messages distributed  
30 within the WLAN network with the purpose to find access relevant information in the messages. To sniff a message means to read not only the source and destination address of a message but also the data of the message without influencing the message. The sender and the receiver of the message do not need to know that the message was sniffed. The messages that are sniffed in the WLAN network 120  
35 comprise access relevant information such as for example the WLAN SS measurements sent from the WLAN-MT 133 to the WLAN network 120 and/or

information regarding the load in the WLAN network, such as the load of the access point that the WLAN-MT 133 has a radio connection with.

5 A number of second listening agents 202 placed in the WCDMA network 110 sniffs existing messages distributed within the WCDMA network with the purpose to find access relevant information in the messages. The messages that are sniffed in the WCDMA network 110 comprise access relevant information, such as the WCDMA SS measurements sent from the WCDMA-MT 132 to the WCDMA network 110 and/or information regarding the load in the WCDMA network, such as the load of the Node  
10 B that the WCDMA-MT 132 has a radio connection with.

The number of first listening agents 203 and the number of second listening agents 202 extract the access relevant information from the sniffed messages within the WLAN network and the WCDMA network, respectively, and send the access relevant  
15 information to an access selection manager 201. The access selection manager 201 receives and compares the WLAN access relevant information received from the number of first listening agents 203 to the WCDMA access relevant information received from the number of second listening agents 202 and, based on this comparison, determines which access network the terminal 130 should access. This  
20 determination may for example result in a handover decision from one access network to the other, which decision is then communicated from the access selection manager 201 to the terminal 130. An access selection client 134 in the terminal 130 then initiates a mobile IP handover from one access network to the other. Alternatively, the decision is communicated to one or both networks, which initiates a network  
25 controlled handover.

Some access relevant information regarding similar quantities for different networks are not directly comparable. Therefore, the information may have to be converted to an access-independent quantity before the access relevant information for different  
30 networks is compared in the access selection manager 201.

Also, at least part of the access relevant information from the WCDMA network could, according to the invention, except from being extracted from existing messages within the WCDMA network, also be obtained as standardised messages received on a  
35 dedicated channel from the WCDMA network to the access selection manager, e.g. from a common radio resource management server in the WCDMA network.

Figure 3 is a schematic block diagram illustrating an embodiment of a listening agent 203 and an access selection manager 201 according to the present invention. The listening agent 203 is placed in a node in an access network, and it comprises a listening unit 301 that is arranged to sniff messages sent within the access network and to extract access relevant information from the sniffed messages. The listening agent 203 also comprises a communication interface 302 that is arranged to send the extracted access relevant information to the access selection manager 201. The access selection manager 201 comprises a communication interface 303 arranged to receive the access relevant information from the listening agent 203. The access selection manager 201 is illustrated with a single communication interface 302, but it is also possible, and probable, that the access selection manager has several communication interfaces communicating with several listening agents. The access selection manager also comprises a processing unit 304 arranged to compare access relevant information received from listening agents placed in different access networks. The processing unit 304 is also arranged to determine which of the different access networks a terminal should access based on the comparison of the access relevant information received from the listening agents placed in the different access networks. Since the determination may result in a handover decision from one access network to another access network, the access selection manager may also comprise a sending unit 305 that is arranged to communicate handover decisions from the access selection manager 201 to the terminal 130. Alternatively, handover decisions may be communicated to one or both involved access networks, which then initiates a network controlled handover.

Figure 4 shows a WCDMA/GSM network 110 comprising a WCDMA radio access network (UTRAN) 401 and a GSM EDGE radio access network (GERAN) 402, connected by a core network 112. In this figure, existing internal interfaces are shown over which interfaces messages are sent that comprise access relevant information. Listening agents according to the invention may be used anywhere in this network to sniff messages sent over the internal interfaces and extract the access relevant information from the messages sent over the shown internal interfaces in the WCDMA/GSM network. The WCDMA radio access network 401 comprises among other things an RNC 113 and a Node B 114, 115. The GSM EDGE radio access network 402 comprises among other things a BSC 116 and a BTS 117, 118. Messages sent over the A/Gb-interface 406 between the GERAN 402 and the core network 112

may comprise access relevant information such as handover/relocation information (i.e. information necessary for performing a handover) and load information that could be sniffed and extracted according to the invention. Other examples of interfaces over which messages are sent that may comprise access relevant information such as

5 handover/relocation information and load information that could be sniffed and extracted according to the invention are the Iu-interface 404 between the UTRAN 401 and the core network 112, the Iurg-interface 407 between the UTRAN 401 and the GERAN 402, the Iub-interface 410 between a Node B 114, 115 and an RNC 113, the Abis-interface 411 between a BTS 117, 118 and a BSC 116, and the Iur-interface 405

10 between RNCs 113 within the UTRAN 401. It would also be possible to sniff and extract access relevant information from messages sent over an interface 408 between a common radio resource management (CRRM) server 403 and the UTRAN 401, and over an interface 409 between the CRRM server 403 and the GERAN 402. The CRRM server collects cell load information from RNCs and BSCs, information that is used to

15 handle radio resources in a communication system comprising only a WCDMA/GSM network 110. The CRRM server and its function is described in prior art document 3GPP TR 25.891 V0.3.0 mentioned above. According to the invention, listening agents may be situated in both the CRRM server and in nodes in the WCDMA/GSM network.

20 In figure 5 an exemplary embodiment of the invention is shown where access relevant information is extracted from messages communicated within a WLAN network according to the Inter Access Point Protocol (IAPP). The IAPP is a communication protocol used by the management entity of an access point 124 to communicate with other access points 125, 126, 127 when various local events occur in the access point

25 124. A listening agent 501, 502 placed at a node that connects access points can sniff IAPP messages communicated between these access points, extract access relevant information from the IAPP messages and send the information to the access selection manager 201. A listening agent can suitably be placed within a layer 2 switch 122, 123, which is directly connected to one or more access points 124, 125, 126, 127. By

30 placing the listening agents in the layer 2 switches 122, 123 the number of listening agents necessary for detecting access relevant information for the terminals in the network will be minimized. The access relevant information is received according to this embodiment of the invention by sniffing either IAPP ADD-notify messages and IAPP MOVE-notify messages or layer 2 update frames, which are sent after a terminal

35 has associated or reassociated with a new access point, i.e. after a terminal has connected or reconnected with a new access point. By listening to these messages,

information of the source and/or destination access point for the communication exchange as well as terminal identity can be detected and extracted from the messages. The information of source and destination access point for a communication exchange can be used in the access selection manager to e.g.

5 calculate the load of an access point. The process of extracting this access relevant information is shown below in association with figure 6 for IAPP ADD-notify messages, in association with figure 7 for IAPP MOVE-notify messages and in association with figure 8 for Layer 2 update frame messages.

10 The IAPP ADD-notify message 600 provides information that a terminal has associated with a first access point. The IAPP ADD-notify packet is sent over the User Datagram Protocol (UDP) and IP on the local LAN segment to notify other access points within the network that the terminal has associated with the first access point, wherein the IAPP ADD-notification uses the IAPP IP multicast address, the source IP  
15 address and MAC address of the access point. The source IP address of the access point is found in the IP-header of the IAPP message. The content of an IAPP ADD-notify message is shown in figure 6. The IAPP ADD-notify message 600 contains information about the IAPP version 601, which IAPP command 602 it is (0 means ADD-notify), and the message data 603. The message data contains the address  
20 length 604, a reserved field 605, the MAC address 606 of the terminal and the sequence number 607. This message will always be sent whenever a terminal associates with an access point and the purpose of the message is to remove stale associations in other access points. A listening agent that is placed in the nearest layer 2 switch sniffs this IAPP ADD-notify message, extracts the information about the  
25 terminal address from the MAC address field 606 and sends this information to the access selection manager, together with the source IP address of the access point that the terminal has associated with, which is extracted from the IP header of the IAPP message. The access selection manager then knows that a terminal with this MAC address has associated with the access point with this source IP address.

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The IAPP MOVE-notify packet provides information that a terminal has reassociated with a new access point. The IAPP-MOVE-notify packet is sent directly to the old access point using TCP/IP, requesting the old access point to remove the terminal from its table and to forward any stored context for the terminal by sending a MOVE-  
35 response message, and in the MOVE-response message requesting the new access point to add the terminal and the context to its own table. The content of an IAPP

MOVE-notify message is shown in figure 7. It differs from the content of the IAPP ADD-notify message shown in figure 6 in that the message data 603 also contains a part defining the length of the context block 708 and the context block 709. The IAPP command byte 602 reveals whether it is a MOVE-notify message (command byte = 1) or an ADD-notify message (command byte = 0). A listening agent that is placed in the nearest layer 2 switch sniffs the IAPP MOVE-notify message, extracts the information about the terminal address in the MAC address field 606 and sends this information to the access selection manager, together with the source IP address of the access point that the terminal has associated with, which is extracted from the IP header of the IAPP message. The access selection manager then knows that a terminal with this MAC address has reassociated with the new access point with this source IP address.

The access selection manager uses this information together with earlier received information regarding other terminals that has associated or reassociated with the different access points as an indication of the load of the access points. The load of the access points can then be used by the access selection manager when determining which access network a terminal should access.

In case of encrypted communication it is possible that the IAPP communication is encrypted. Then information cannot be extracted from the IAPP MOVE-notify and IAPP ADD-notify messages, but it is still possible to listen to Layer 2 update frame messages, for example by a listening agent placed in the Layer 2 switch. The Layer 2 update frame message follows IAPP MOVE-notify messages and IAPP ADD-notify messages. The Layer 2 update frame message is an 802.11 type 1 Logical Link Control (LLC) Exchange Identifier (XID) Update response frame with the content shown in figure 8. The Layer 2 update frame message 800 contains a MAC destination address (MAC DA) 801, which is the broadcast MAC address to all devices connected to this segment, and a MAC source address 802, which is the MAC address of the terminal that has associated/reassociated. It also contains information about frame length 803, destination service access point (DSAP) 804, source service access point (SSAP) 805, a control bit 806 and an XID information field 807. DSAP and SSAP are used to identify which upper layer protocol that is used. The purpose of the Layer 2 update frame message is to update all Layer 2 devices (e.g. bridges, switches and other access points) in order for them to reach the new location (access point) of the terminal. According to the invention, a listening agent that is placed in the nearest layer 2 switch listens to this Layer 2 update frame message, extracts the information about

the terminal address in the MAC source address field 802 and sends this information together with the ID of the new access point to the access selection manager. The ID of the new access point is extracted by identifying which port this message is received on in the layer 2 switch. The access selection manager then knows that a terminal with this MAC address has reassociated with the new access point that sent this message.

Both the access relevant information extracted from the IAPP messages and the Layer 2 update frames enable the access selection manager to keep track of the number of associated terminals in each access point. This is used by the access selection manager as a load measure when comparing the WLAN network with other access networks. Note that there is no message that tells the access selection manager that a terminal has stopped using the access point. One solution for the access selection manager to find out if a terminal is no longer active is to associate an inactivity timer with each terminal listed in the access selection manager and remove the terminal from the access selection manager list of associated terminals if no handover has taken place within a certain time. Another more detailed solution is to listen to the user plane traffic for each terminal in the listening agents and use this as input whether the terminal is active or not. User plane traffic means the data traffic to and from a terminal. In this case, if no user plane traffic has been received or transmitted within a certain time, the terminal is removed from the access selection manager list of associated terminals.

The user plane traffic may also be monitored for other reasons. By letting the listening agents listen to the user plane traffic, it is possible to extract and calculate traffic volume (total number of bits transmitted) and throughput (bits/second) for each terminal, which would provide a more detailed level of load information at each access point. This more detailed load information may be used by the access selection manager to more accurately manage the radio resources. Listening agents for listening to the user plane traffic may be situated in the layer 2 switches that are directly connected to an access point or they may be situated directly in each access point.

Below another exemplary embodiment of the invention is shown describing how access relevant information can be extracted from messages communicated within a WLAN network. In this exemplary embodiment, access relevant information is extracted from messages sent according to a protocol called Light Weight Access Point Protocol (LWAPP). LWAPP is a protocol allowing a router or switch to interoperably

control and manage a collection of wireless access points. The LWAPP protocol comprises the message categories packet forwarding and access router configuration, which may contain access relevant information.

5 In packet forwarding, packets to/from mobile terminals are forwarded to/from an access router via an access point encapsulated in LWAPP packets. Uplink packets (i.e. packets sent from a terminal to an access point) include access relevant information such as the signal strength and the signal to noise ratio with which an 802.11 frame was received by the mobile terminal over the radio interface. These packets may  
10 according to the invention be sniffed by a listening agent placed e.g. in the access router. The listening agents may except from being situated in the access router be situated closer to the access points or in the access points. The listening agent extracts the access relevant information and sends this information to the access selection manager.

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Access router configuration messages are used by the access router to push a specific configuration to the access points it has a control channel with. Messages that deal with the retrieval of statistics from the access points also fall in this category. Especially the messages that deal with the retrieval of statistics contain access  
20 relevant information. The statistics is included in a Statistics Report LWAPP message sent from an access point to the access router. This message contains a number of counters indicating the operational status of the access point's transmission and reception of data frames. Examples of statistical counters included in the message are the "Tx Fragment Count" and "Rx Fragment Count" that indicate the number of  
25 fragmented frames transmitted and received by the access point, respectively. Since the Statistics Report LWAPP message is sent repeatedly, these two counters can be used to calculate the average downlink and uplink load for the particular access point between two received statistics messages (previous message is received at time "time old" and the last message is received at the time "time new", time is elapsed seconds),  
30 measured in transmitted (or received) number of fragmented frames per second using the following formulas:

Downlink load = (Tx frag new - Tx frag old) / (time new - time old), where  
"Tx frag new" is the received value of the "Tx Fragment Count" at the time "time new",  
35 and "Tx frag old" is the received value of the "Tx Fragment Count" at the time "time old".



Uplink load = (Rx frag new - Rx frag old) / (time new - time old), where  
"Rx frag new" is the received value of the "Rx Fragment Count" at the time "time new",  
and "Rx frag old" is the received value of the "Rx Fragment Count" at the time "time  
5 old".

A listening agent situated e.g. in the access router may extract the Tx fragment count  
and the Rx fragment count from the Statistics Report LWAPP message and send this  
information to the access selection manager, which may calculate the uplink or  
10 downlink load for the respective access point according to the above. The calculation  
may also be done in the listening agent.

Below another exemplary embodiment of the invention is shown on how access  
relevant information is extracted from messages communicated within a WLAN  
15 network. In this example, access relevant information is extracted from messages sent  
according to a protocol defined by an IEEE emerging standard called 802.11k. This  
emerging standard will define measurement reports comprising measurements of  
radio conditions, such as received signal power. It will also define reports comprising  
load measurements, for example indicating how large portion of the time a WLAN  
20 channel is busy, which is indicated by the clear channel assessment (CCA) busy  
fraction. A WLAN channel is a connection to an access point that can be used by  
many terminals. This access relevant information may be extracted from the messages  
containing the measurement reports by a listening agent placed e.g. in the access  
point sniffing the channel load reports.

25 The access relevant information extracted as described in the examples above is then  
sent to an access selection manager to perform multi-access related decisions, by  
comparing the access relevant information from one network, e.g. WLAN with access  
relevant information from other networks such as WCDMA and/or GSM networks. For  
30 example, the WLAN signal strength measurements collected from e.g. packet  
forwarding in LWAPP are compared to similar measurements for WCDMA and GSM to  
form the basis of determining whether a particular mobile terminal is best served by a  
particular WLAN access point or GSM/WCDMA cell.

35 Access relevant information from different networks is in many cases not directly  
comparable. Therefore, to enable a determination whether a terminal is best served in

a first or a second network, it may be necessary to convert access relevant information from the first and/or the second network into comparable quantities. This conversion takes preferably place in the access selection manager, but it may also take place in the listening agent. Below is shown examples of how to convert and compare access relevant information such as signal strength and load to quantities comparable between GSM, WCDMA and WLAN.

A first example describes how to convert load measurements from different access networks into comparable quantities. Load measurements from GSM and WCDMA has according to prior art been normalised by the BSC and the RNC towards a linear scale (0-100) where 100 represents the maximum planned load. The WLAN load measure "number of associated users", extracted from sniffing e.g. IAPP communication, and compiled in the access selection manager is therefore also converted towards a linear scale between 0-100. The conversion is done according to the following: If in this example it is assumed that an access point has been dimensioned to handle N associated terminals and the access point currently has n associated terminals, the following formula gives a load measure comparable to the WCDMA and GSM load measure:

$$\text{WLAN load measure} = n/N \cdot 100$$

Thereby, the different load measurement quantities have been converted to the same comparable quantity, and may be compared with the purpose of determining which access network a terminal should access.

Another example of converting access relevant information into comparable quantities describes how to convert a WLAN channel load measurement extracted for example from 802.11k measurement reports to a load measure on a scale between 0-100, i.e. comparable to the load measurements that can be extracted from GSM and/or WCDMA. From the 802.11k measurement reports the measure Clear Channel Assessment (CCA) Busy Fraction is extracted, which contains information of how large portion of the time the channel was busy during the measurement duration, which indicates channel load. As WLAN is using terminal based CSMA (Carrier Sense Multiplex Access) as opposed to WCDMA where the network schedules resources, the delay will increase exponentially for WLAN when the load is increased compared to WCDMA where the delay will in practise be very low until a fully loaded system is reached. Therefore, the invention proposes to introduce a conversion function to be

able to perform a fair comparison between such load measures for CSMA (WLAN) and network based scheduling systems (GSM or WCDMA).

$$\text{Load\_measure\_network} = F(\text{load\_measure\_csma})$$

5 Also, measurements regarding radio connections for different access networks may need to be converted into comparable quantities before they are compared. For WLAN, the measurement values indicating radio conditions e.g. signal power used in downlink or uplink, signal strength or signal to noise ratio may be extracted from different messages sent within the WLAN network. For WCDMA, the received signal  
10 code power (RSCP) measurement can be extracted from the RRC MEASUREMENT REPORT message sent from the mobile terminal to the RNC, when the mobile terminal has an ongoing WCDMA connection. An alternative is to extract  $E_c/N_o$  measurement values indicating signal quality. For GSM, for example the SSLEV (signal strength) and SQUAL (signal quality) measurement values sent in MEASUREMENT REPORT  
15 messages from the mobile terminal to the BTS and then to the BSC can be extracted. The WLAN, GSM and WCDMA measurement values are sent to the access selection manager and converted to a comparable quantity before they are compared.

The access selection manager according to the invention is for the sake of simplicity  
20 shown in the figures as one functional entity residing in one place, but the function of the access selection manager might as well be distributed.

Figure 9 is a flowchart describing an exemplary embodiment of a method according to the invention for managing radio resources for providing wireless access to a  
25 communication system to a number of terminals, wherein the communication system comprises a first access network using a first access technology and at least one second access network using at least one second access technology different from the first access technology.

30 The method starts by listening 901 to messages sent within at least the first access network with the purpose of finding access relevant information in the messages. This step of listening to the messages sent within at least the first access network is preferably done by sniffing the messages. The found access relevant information is then extracted 902 from the sniffed messages. Thereafter, the extracted access  
35 relevant information is received 903 by a common access selection manager function, which also receives access relevant information from the at least one second access

network. The access relevant information received from the at least one second access may be extracted from messages sent within the at least one second access network in the same manner as for the access relevant information in the first access network, but it may also be received in another way, for example as a standardised message on a dedicated channel. After being received, the access relevant information from the different networks is converted 904, if necessary, to a comparable, and preferably access-independent quantity. This step of converting 904 access relevant information may be omitted if the access relevant information from the different networks are already expressed in comparable quantities. When the access relevant information received from the different access networks are expressed in comparable quantities they are compared 905 with the purpose of determining 906 which access network a terminal should access.

As shown in the application, the object of the invention is to achieve a solution for managing radio resources for providing wireless access to a communication system consisting of access networks using different access technologies, and wherein the solution can easily be adapted to manage radio resources for providing wireless access to a system that is expanded with a first access network using a new access technology. This is achieved by receiving access relevant information from the first access network and at least one second access network, wherein the received access relevant information comprises information extracted from messages sent within the first access network. It is further achieved by comparing the received access relevant information extracted from messages sent within the first access network to access relevant information received from the at least one second access network, and determining which access network a terminal should access based on the comparison of the received access relevant information extracted from messages sent within the first access network to the access relevant information received from the at least one second access network.

In the drawings and specification, there have been disclosed preferred embodiments and examples of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation, the scope of the invention being set forth in the following claims.